2nd European Fluid Dynamics Conference (EFDC2)
26 – 29 *August* 2025*, Dublin, Ireland*

Interactions between internal gravity waves and turbulent eddies in bidimensional stratified turbulence

Romain Vallon *, Jakob Albert †, Alexandre Delache *, ‡ and Fabien Godeferd *

Internal gravity waves can be observed in fluids with stable density stratification, such as oceans and parts of the atmosphere, in addition to turbulence. In stratified turbulence, the internal gravity waves can interact with the turbulent eddies over a wide range of scales [1]. The signature of such waves in stratified turbulence were observed experimentally [2] and numerically [3]. However, the understanding of the two-way coupling between waves and eddies is still an open question. Can a general picture of this coupling be drawn in terms of spatial scales? Our study focuses on 2D turbulent stratified flows, whose configurations are close to experimental soap films [4]. We carried out a campaign of Direct Numerical Simulations (DNS) to study strongly stratified flows in the transition region between wave turbulence and strongly stratified turbulence. The DNS span a decade of Brunt-Väisälä frequency, $N \in [1, 10]$ Hz. In order to quantify the waves-eddies interactions, the flow is decomposed into three fields containing either the large scales, the internal gravity waves or the turbulent eddies [5]. Figure 1 depicts the decomposition of our 2D data into the eddy and wave fields. Overall, the joint distributions of the norm and direction of the velocity vector show that velocity is preferentially aligned with the stratification layers in the whole field and in the wave field. However, one observes different trends depending on the stratification intensity. For stronger stratification ($N = 10$ Hz), the velocity is preferentially aligned with the stratification layers, while it does not show preferential orientation for lighter stratification ($N = 1$ Hz), as in homogeneous isotropic turbulence. Additionally, we will discuss the distribution in scales of the velocity increments of order 2, that convey the energy distribution, order 3, for the direction of the energy cascade, and order 4, for the intermittency, separately for the wave and eddy fields.

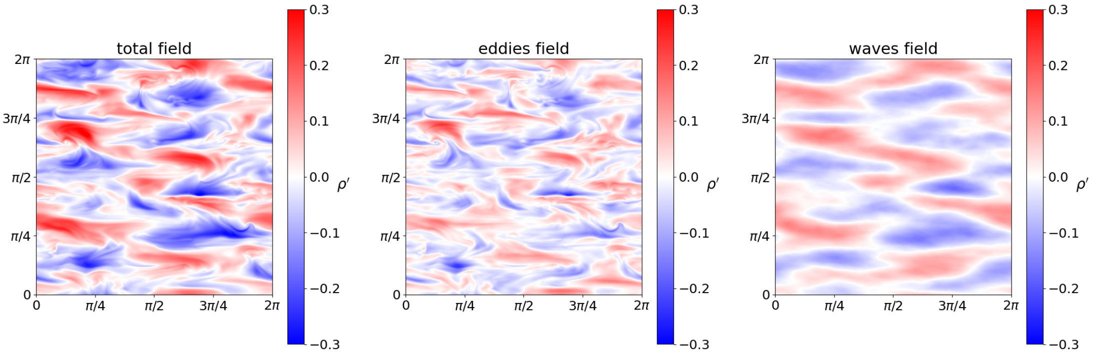

Figure 1: Visualisation of the buoyancy variation ρ' of the whole field (left), the eddy part (middle) and the wave part (right) in the case of a lighter stratification, where the Brunt-Väisälä frequency N equals to 1 Hz.

*École Centrale Lyon, CNRS, Université Claude Bernard Lyon 1, INSA Lyon, LMFA UMR 5509, 69130, Écully, France.
†Chair of Fluid Dynamics, TU Darmstadt, Otto-Berndt-Str. 2, 64287, Darmstadt, Germany.
‡Université Jean Monnet, 42100, Saint-Étienne, France.
[1] M. C. Gregg, *J. Phys. Oceano.*, **7**, 436–454 (1977)
[2] C. Savaro et al., *Phys. Rev. Fluids*, **5**, 073801 (2020)
[3] P. C. di Leoni et al., *Phys. Rev. E*, **91**, 033015 (2015)
[4] A. Monier et al., *Phys. Rev. Fluids*, **9**, 124001 (2024)
[5] H. Lam et al., *J. Fluid Mech.*, **923**, A31 (2021)